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ABSTRACT

In this study an attempt was made to obtain a developmental dimension for estimating longitudinal development on the basis of cross-sectional data. To check the validity of this approach, the cross-sectional data were compared with true longitudinal data. Forty-three public school children were given a series of conservation tasks in four assessment periods, each 15 months apart, during their first four years of school. Results indicated that: (1) cross-sectional data on cognitive development, when scalogram analyzed, can predict longitudinal direction of development; (2) such developmental scales may better characterize a child's present level of development than deviance scores on IQ-tests; (3) such scales are useful for studying the development of individuals as opposed to groups; and (4) these scales may be helpful in comparing individual rates of development. (ED)

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A FIVE-YEARS FOLLOW-UP STUDY ON COGNITIVE DEVELOPMENT IN GRADE-SCHOOL CHILDREN

unrevised paper
given at

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A Five-Years Follow-Up On Cognitive Development In Grade-School Children.

Longitudinal studies on cognitive development have been relatively rare: they are time-consuming, expensive, and suffer from many methodological shortcomings.

Especially in the area of reasoning, alternative ways of getting at longitudinal development have been tried. One of these ways is to take a sample of children from one age group but differing levels of development and administer tasks that are supposed to represent a developmental dimension at different levels of attainment. A scalogram analysis then will show if the answers really follow a Guttman-scale, i.e., if the rank-order of difficulties holds true for all children, and if the easier items are always solved before the more difficult ones. Such Guttman-scales have become quite popular for getting quasi-longitudinal information.

Conventional tests of cognitive performance do show differences within age-groups. Repeated measures on these tests tell you something about changes relative to the respective age-groups. They do not, however, provide data about either the child's cognitive developmental level nor about his actual developmental progression.

In the present study an attempt was made to obtain a developmental dimension on the basis of cross-sectional data. In order to check the validity of this approach, the cross-sectional data were compared with true longitudinal data.

We were trying to answer the following questions:

1) Is there a unidimensional sequence of tasks for all children?
2) From knowing one particular child's position on the scale, can one predict his rate of development by comparing his score at a given time with scores of his peers?

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Methods

The instruments used in this study are listed in Table 1. As you can see, there were 4 assessments, at 15 months intervals. During the first two, the following reasoning tasks were administered:
conservation of number, using 3 different kinds of materials,
conservation of length, using the Müller-Lyer illusion as well as the regular Piaget paradigm,
conservation of substance, using clay balls
and conservation of inequality of liquid.

Most of the children could solve almost all of these problems by the second assessment, except for the conservation of liquid task. Therefore a new set of more difficult tasks was used for the 3rd and 4th assessment. Fig.1 gives a brief summary. The tasks consisted of:

conservation of divided length (only the transformed row is shown in the figure),
conservation of area, using two different paradigms,
conservation of weight of dissolved sugar,
conservation of liquid inequality - the first two items having been retained from the first two assessments,
conservation of filled and empty space,
conservation of time and speed,
and a formal thinking task.

Again, the fourth assessment followed the third after 15 months, using the same procedure.

Two kinds of scoring were used. First, all items were scored separately according to correct or incorrect answers and summed up to a Total Item Score. Second, items belonging to the same task - defined as tapping the same concept by using the same material and the same basic paradigm - were scored together and summed up to a Total Task Score.

The individual item analysis was retained to guard against possible misgroupings and for scalogram analysis.

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Subjects

Subjects were all the children in a small town 10 miles south of Bonn, who entered grade school in 1968. A few children moved away within the first half year. However, out of 45 children at the end of first year, 43 still could be reached at the same school at the end of their fourth year of schooling.

FIG. 2 shows the socioeconomic background of the sample as obtained from fathers' education and occupation. 42 out of 43 subjects lived with their natural parents, one child is not included in the graph because he lived only with his mother. As can be seen, most fathers hadattended Volksschule (public school grades 1-8) and had a 3 years vocational training. Fathers with "Fachschule" and "Fachhochschule", which corresponds roughly to college, and those with university training are slightly overrepresented.

At the first testing, the children's ages were between 5-10 and 7-1 ys with a mean of 6-5 years; at the last assessment, they were between 9-9 and 11-1 years old with a mean of 10-3 years.

Results

1. Changes in Performance on the Piaget tasks

FIG. 3 and 4 show the distribution of scores for the total sample during the first and second assessments. As often can be seen with developmental data, the distribution of performances is far from normal. At the first testing, most children either answered correctly on a few items or on nearly all items; at the second testing 12 months later, most children got high Total scores. These results are even more pronounced, when Total Task Scores are considered instead of Total Item Scores.

FIG. 5 and 6 show the distributions of Total Item Scores and Total Task Scores, resp., at the third and fourth assessment. Again, the distributions do not fit a normal curve but rather show two or three peaks at the low, middle and high end of the scale.

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These results show:

1) marked increases in correct answers for the total sample, which are statistically significant,

2) a tendency toward developmental "levels", marked by peaks in the distributions,

3) the fact that only a few children had full access to conrete reasoning by the age of 10 or 11 or by the end of their fourth year at school, resp.

This analysis, however, leaves some questions unanswered:

1) Is there a consistent order in the kinds of tasks solved?

2) Do all children show a similar developmental progression from one assessment to the next?

3) Do some children regress?

2. Changes in difficulty levels of Piaget tasks

Difficulty levels of tasks may indicate a developmental sequence, esp. when they follow a Guttman-scale. If they really represent a developmental order, the sequence should hold even when the absolute difficulty of solving the items decreases, for instance with increasing age of the child.

FIG. 7 shows the changes in difficulty levels of the conservation tasks from the first to the second assessment. Only the first task is not represented, since its function as first and warm-up item camouflaged its cognitive status. Clearly, more children conserved on all of these task on the second assessment. The pattern of sequence, however, was not retained, except for the hardest task, conservation of liquid inequality. Interestingly, however, the easiest task at the first assessment, the Muller-Lyer length illusion, improved least. There are several indications that it changes its meaning relative to the cognitive level of the children.

The 1969 results will not be discussed at length because the tester involved may have influenced subjects' answers by suggestive questioning.

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The 1968 results, however, not only represent different levels of difficulty but also follow a Guttman-scale quite well. A scalogram analysis on the tasks yielded a Green-Index of reproducibility of I = .759, which is quite acceptable.

Since the results on the first set of tasks are less conclusive I shall concentrate on the second set of items administered at the third and fourth assessment.

FIG. 8 shows the general progression in each item from the third to fourth assessment. Though there are slight changes in sequence esp. among items which had been at the same level of difficulty, the general trend remained. Increases of correct answers were most marked in items of intermediate difficulty, which were those of conservation of divided lengths and conservation of liquid amount when a ball was put into the water. The easiest tasks in these two assessments, nos. 1o and 11 - conservation of liquid inequality - had been the hardest in the first two assessments; the hardest in 1971-2 was that of formal thinking as was predicted by theory.

Separate scalogram analyses were performed on these items for both assessment periods which yielded acceptable reproducibility indices. If there is a regularity in development, however, similar patterns of tasks should emerge.

Therefore, data from both assessments were entered into a combined scalogram analysis. Six items had to be removed from analysis since they proved responsible for most pattern irregularities. They are separately depicted on the right hand side of Fig. 8. The final scale of 16 items, with the easiest two scored together, yielded an overall Green-Index of I=.75, and separate indices for the two assessment times yielded I=.63 and I=.75, resp..

These indices show that the regularity of pattern improved with higher cognitive levels of the subjects. This result is not unique. A scalogram analysis for the tasks from the first assessment which had proved acceptable for this sample of children then starting school, did not work out much beyond

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chance level for an earlier study which involved 250 children aged 4-6 to 6-0 years who attended nursery schools. It might well be that irregularities are quite common when the difficulty level of tasks is very high. Besides, the tasks used here were not selected according to their logical and psychological relatedness but rather haphazardously from experiences of former studies. Therefore it is a crude instrument, open to chance influences from divergent experiences. Separate analyses on some items which are clearly logically and psychologically related, usually yielded high reproducibility indices even during the third assessment. Even with these restrictions, the results are impressive.

3. Developmental changes of individuals

The Guttman scale that resulted from the scalogram analysis was then used to pinpoint each child's position on this developmental scale in order to check if each progressed in the predicted direction. Figure 9 shows the changes in cognitive level from the third to the fourth assessment. Each child is identified by his code number and ordered along the Y-axis according to his position when first administered this set of tasks. Dotted circles indicate that he had missed one or at most two items along the scale, single dots and single x represent additional correct answers that fell outside the scalogram pattern.

Twelve out of 41 children did not change their status; 4 of them only completed their patterns. Some children show marked progressions, esp. those of formerly intermediate or high status. One formerly complete "non-conserver" progressed considerably (no.2). In general, however, children of formerly low cognitive level progressed little or even regressed. There seems to be no clear way to predict from a child's position at one point of time his development within the next 15 months. Just compare Ss no. 32 and no. 2, or 24, 4 and 29 or 26 and 8. Standstills, progressions or regressions can occur, though progressions prevail.

How do these developmental changes compare with the initial results at the first assessment?

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In Fig. 1o, all individual children are depicted on the left hand side according to their cognitive level before school entrance. The triangles show their positions 15 months later. On the right hand side, their cognitive levels at the third and fourth assessment are represented. At first glance there does not seem to be much regularity. However, children high in cognitive level at school entrance tend to be high at fourth grade as well, and those starting at the lower end have some chance of remaining behind. It might be interesting, however, to note that the children nos. 19 and 11 as well as those with larger regressions, i.e., 4o, 26 and 29, were the only ones who had to repeat a class during the time under study.

4. Speed of development

Generally, we may conclude, that longitudinal development follows a rather definitive direction which can quite well be predicted by scalogram analysis of cross-sectional data, as long as difficulty levels of tasks are intermediate in the respective group. Stagnations, however, are not infrequent, and regressions tend to occur, although they generally correspond to other negative experiences. - By the way, regressions do not tend to follow a backward pattern on the scale, but rather seem to indicate a dissolution of the pattern. -

Individual differences in speed of development seem to be large, although children who are ahead relative to their age-mates seem to stay ahead later on. These results are supported by the correlations of the Total Item Scores between all 4 assessment periods, as reported in Table 2 and the correlations of the Total Task Scores between all assessment periods, as reported in Table 3. A stepwise regression analysis with the Total Scores from the first three assessments entered as independent variables yielded a multiple R^2 = .673 (or corrected for small sample of .645) with the cognitive level at the fourth assessment time; the previous year's cognitive level being the best single predictor (R^2= .57). Knowing a child's long-range development thus adds to the predictability of his further development substantively, although it does not predict it completely.

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What I tried to say is

that cross-sectional data on cognitive development - when scalogram analyzed - can well predict longitudinal direction of development,

that such developmental scales may better characterize a child's present level of development than, for instance, deviance scores on IQ-tests,

that such developmental scales are useful for studying the development of individuals as opposed to groups

and that they may be helpful in comparing individual rates of development.

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H A N D O U T

A FIVE-YEARS FOLLOW-UP STUDY ON COGNITIVE DEVELOPMENT IN GRADE-SCHOOL CHILDREN

Hellgard Ra u h , PH.D.

BIENNIAL MEETING OF
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TABLE 1 : ASSESSMENT PERIODS AND INSTRUMENTS

	Assessment time	set of tasks	kind of tasks	number of items
			1 conservation of number 1	2
1)	June/July 1968	Set I	2 conservation of number 2	2
			3 conservation of number 3	3
			4 conservation of length 1	4
			5 conservation of length 2	7
2)	Oct./Nov. 1969	Set I	6 conservation of substance	3
			7 conservation of liquid	8
			Total: 7 tasks	29 items
			1 conservation of divided lengths	4
3)	Febr./March 1971	Set II	2 conservation of area 1	2
			3 conservation of area 2	1
			4 conservation of weight (dissolved sugar)	2
4)	May/June 1972	Set II	5 conservation of liquid 1	3
			6 conservation of liquid 2	1
			7 conservation of space 1	3
			8 conservation of space 2	2
			9 conservation of time 1	1
			10 conservation of time 2	1
			11 formal thinking	1
			Total: 11 tasks	21 items

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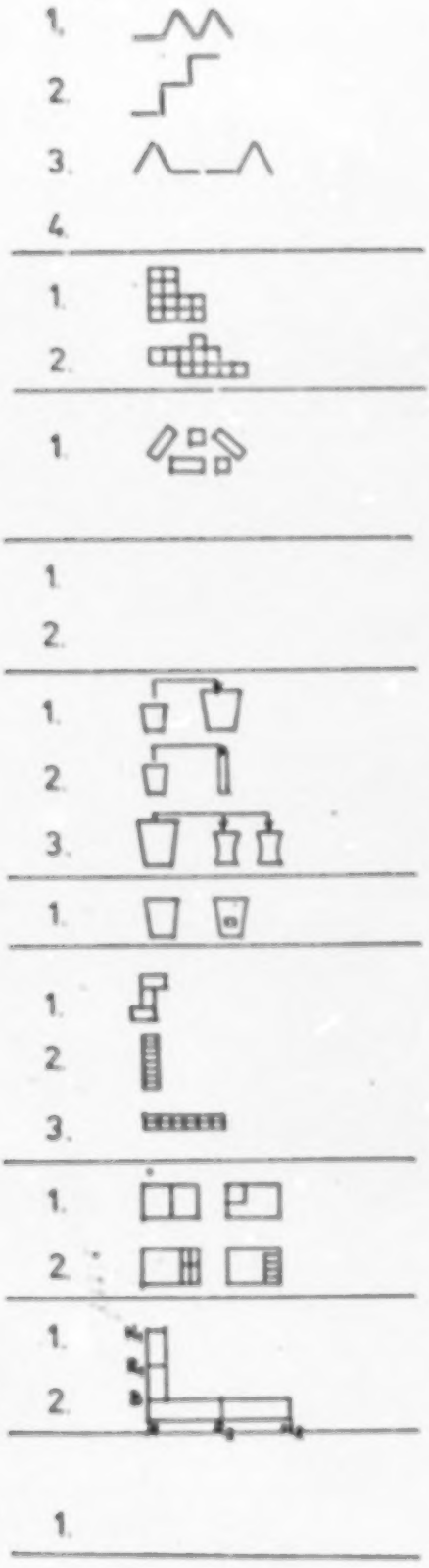

1. Conservation of divided lengths

The comparison row of 5 sticks always remained straight. Only the transformations are shown. In Item 3, one more stick was added to the bent row. In Item 4, the child is shown a bent row and asked to construct a straight "street" of equal length

2. Conservation of area 1
The comparison area consisted of 4x3 pieces. Only the transformations are shown.

3. Conservation of area 2
On the comparison "farm", the houses are placed along one side of the square farm ground. Question is for the amount of grass for the cows.

4. Conservation of dissolved sugar
Item 1: grained sugar is poured in one of two glasses with water. Question for equality of weight.
Item 2: a piece of sugar (same amount) is put into the other glass.

5. Conservation of liquid inequality 1
Only the transformations are shown

6. Conservation of liquid inequality 2
A ball is put into the glass with less water.
Question for amount of water.

7. Conservation of filled space
2 x 12 blocks are stapled into two walls of three block length and 4 blocks height. One wall is trasformed as in Item 1 (view from above), and as in Item 2 and 3 (views from one side). (In Item 2 it should be 12 blocks in height).
Question: which way of stapling takes more space?

8. Conservation of empty space
Two or 4 blocks, resp., are spaced differently in two boxes. Question is for the amount of space left.

9. Conservation of time 1
Two cars start at the same time and stop at the same time, but at different distances (A...R1, B...R2)

10. Conservation of time 2
Start at different times, Stop at same time, same distance (A...R2, B...R1). Question for time used by cars.

11. Formal thinking
Question for number of groups of two (friends walking and talking together) that can be formed by 5 friends.

FIGURE 1: PIAGET REASONING TASKS USED FOR 3rd AND 4th ASSESSMENT

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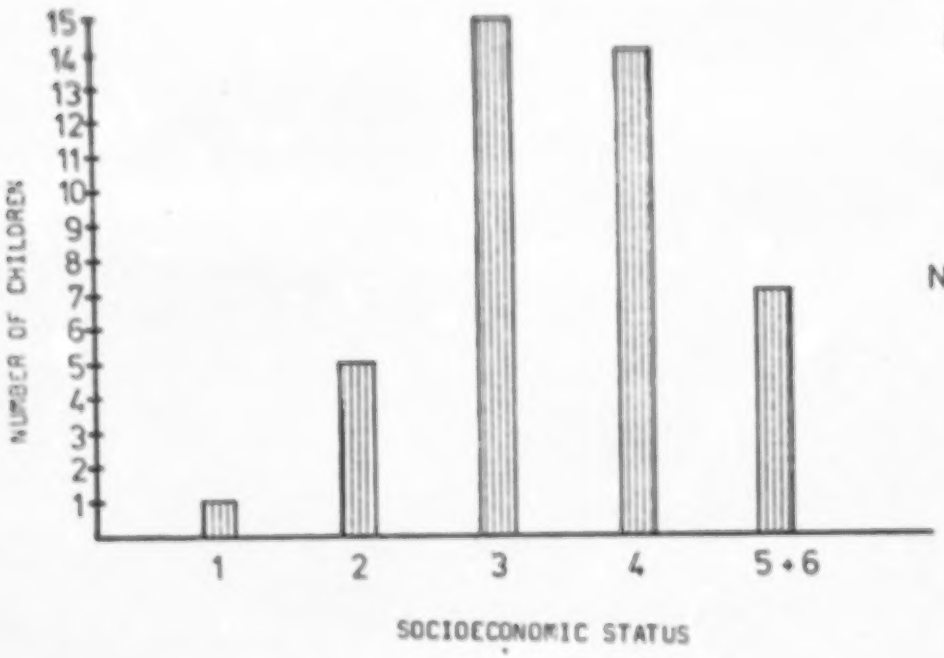

N = 42

1 unskilled workers
2 semi-skilled and skilled workers
3 lower level employees
4 i.e. foremen, store-keepers etc.
5•6 professionals with college or university training

FIGURE 2: SOCIOECONOMIC BACKGROUND OF THE SAMPLE AS RATED FROM FATHERS' EDUCATION AND EMPLOYMENT

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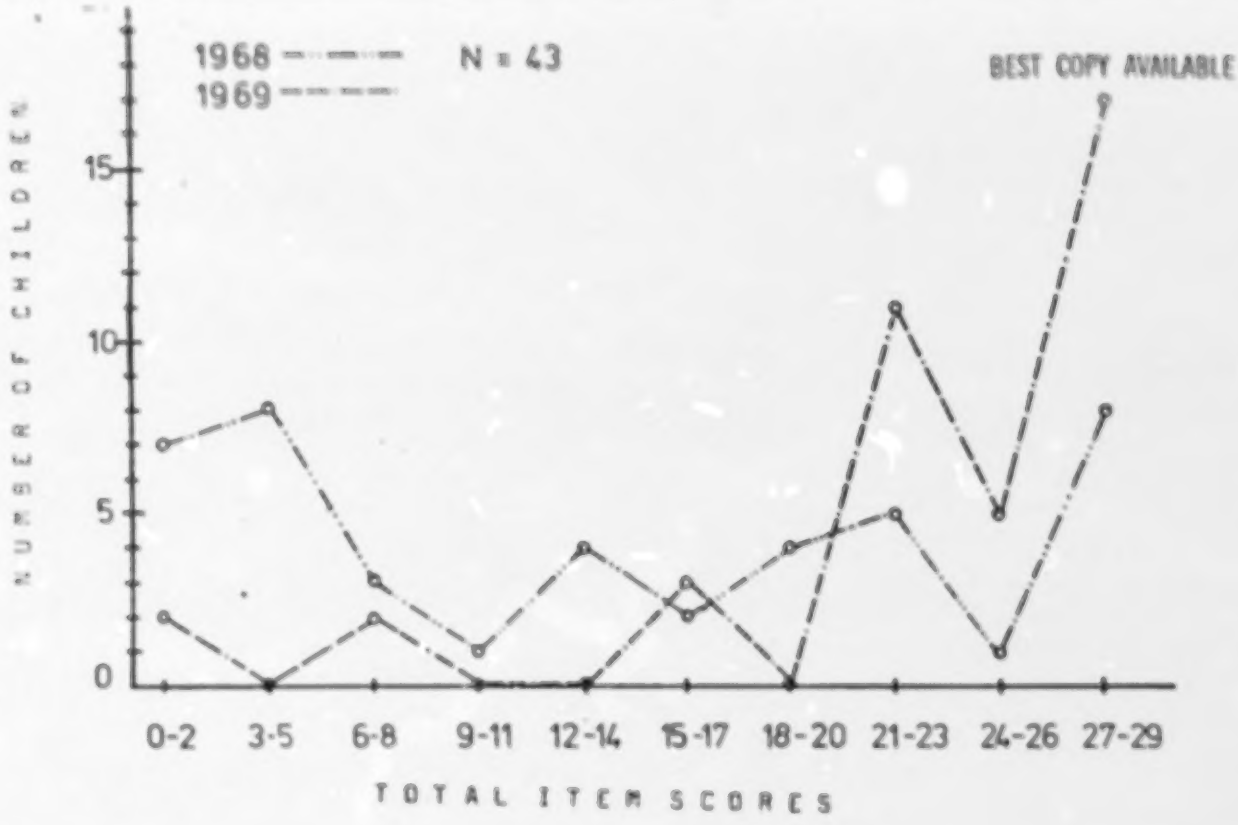

FIGURE 3 : TOTAL ITEM SCORES AT THE FIRST AND SECOND ASSESSMENT

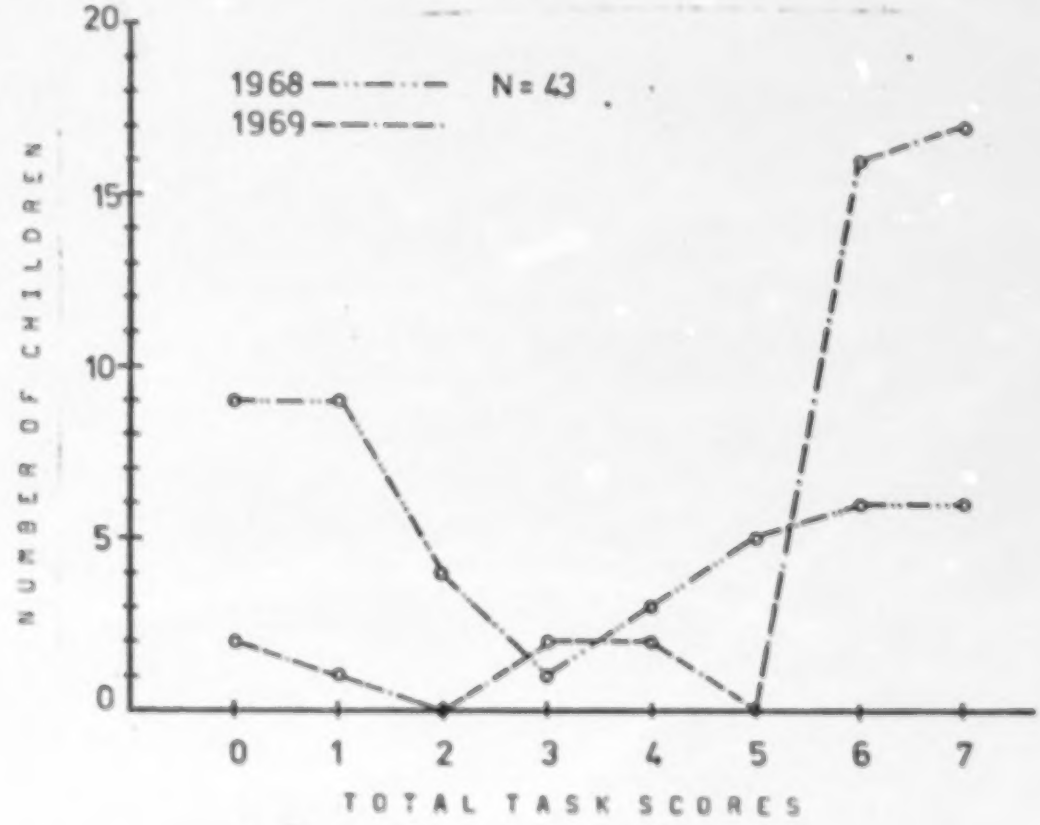

FIGURE 4: TOTAL TASK SCORES AT THE FIRST AND SECOND ASSESSMENT

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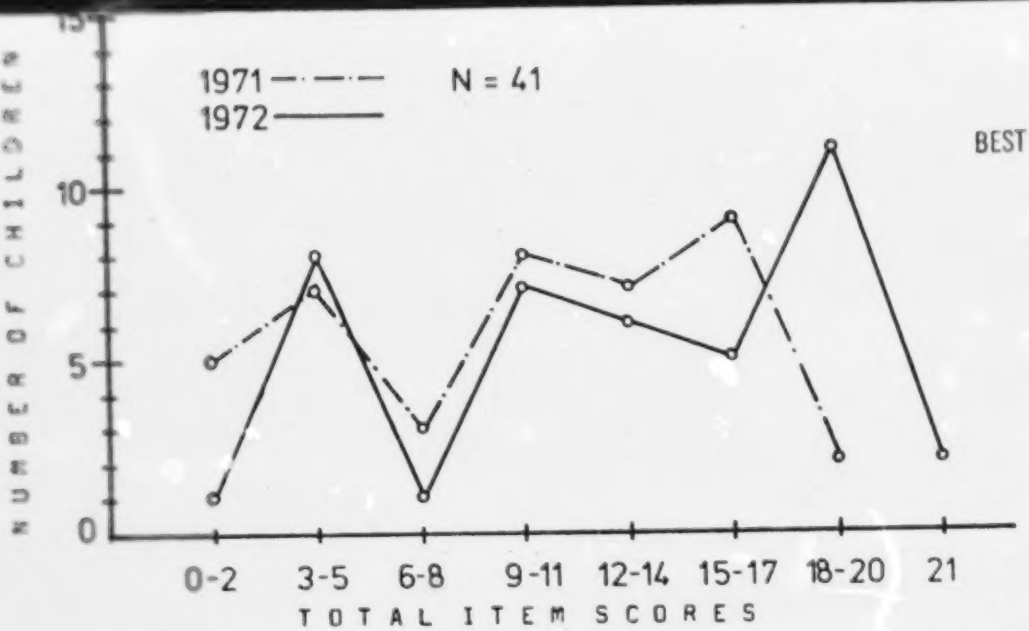

FIGURE 5: TOTAL ITEM SCORES AT THE THIRD AND FOURTH ASSESSMENT

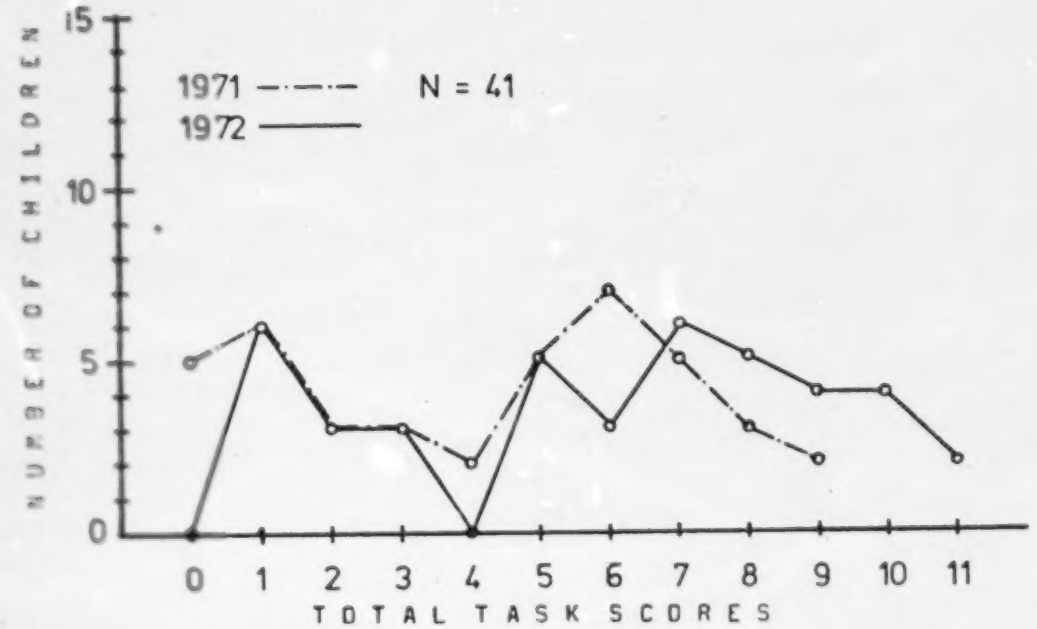

FIGURE 6: TOTAL TASK SCORES AT THE THIRD AND FOURTH ASSESSMENT

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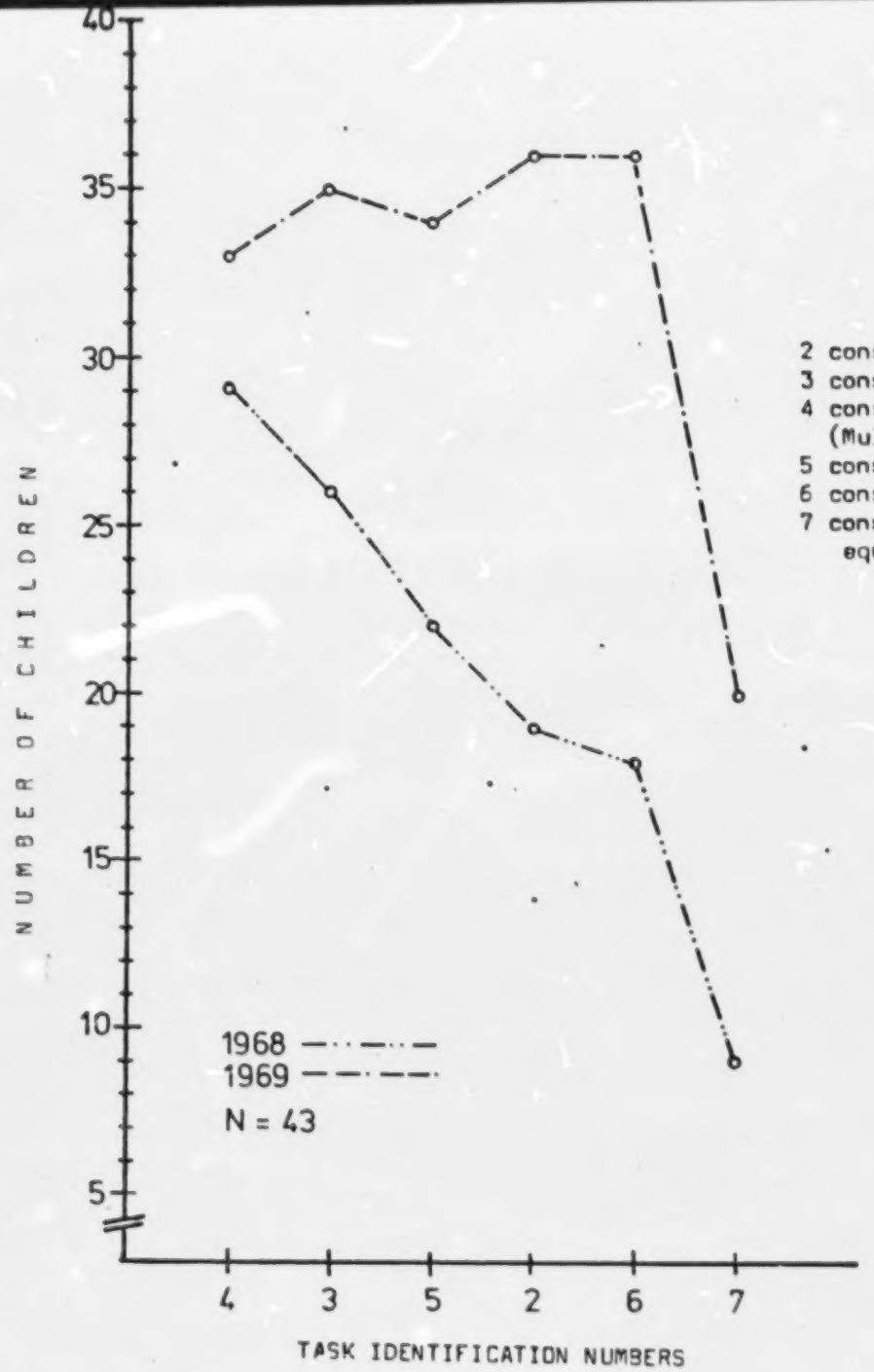

FIGURE 7: CHANGES IN DIFFICULTY LEVELS OF CONSERVATION TASKS FROM THE FIRST TO THE SECOND ASSESSMENT

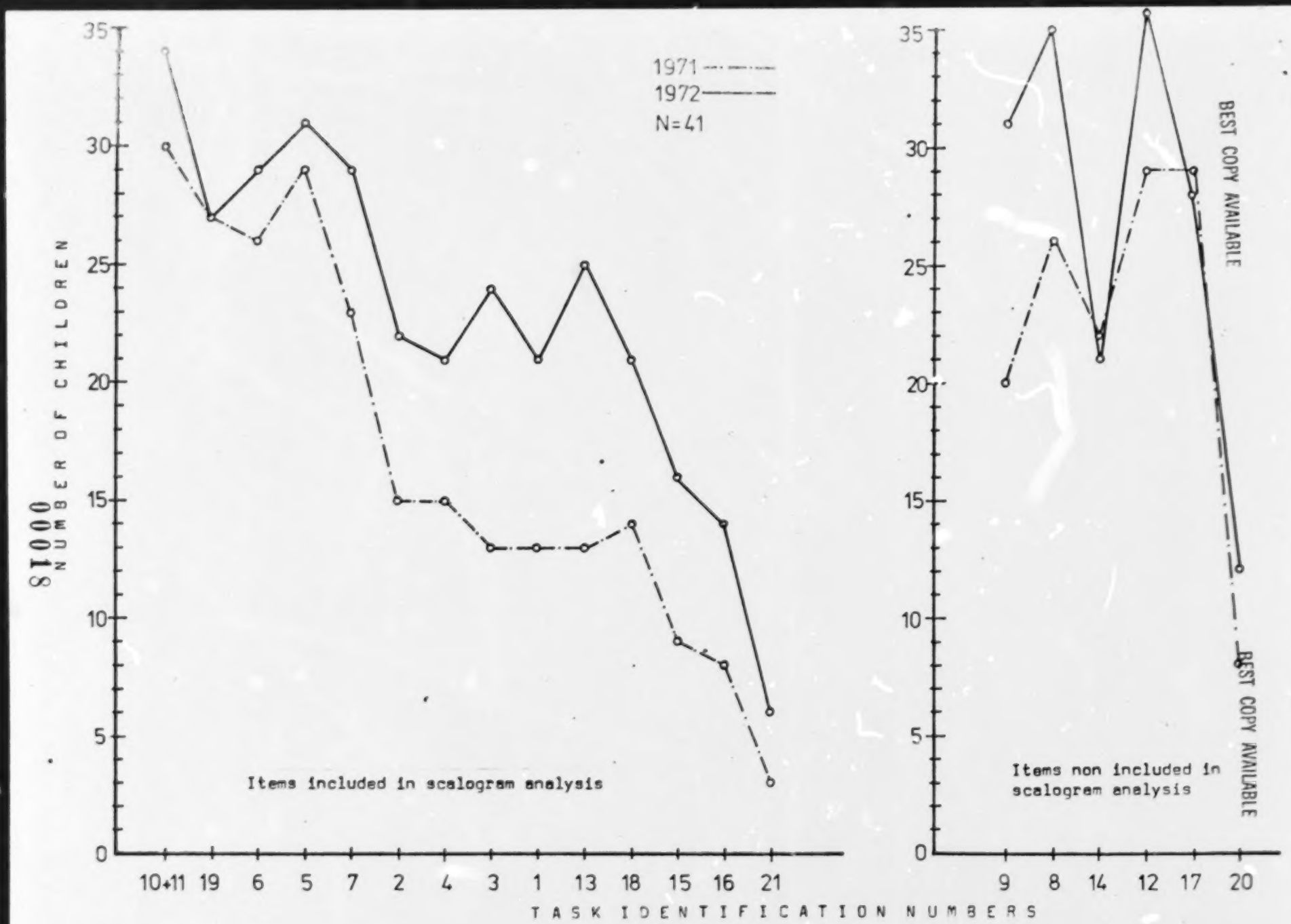

FIGURE 8: CHANGES IN DIFFICULTY LEVELS OF REASONING TASKS FROM THE THIRD TO THE FOURTH ASSESSMENT

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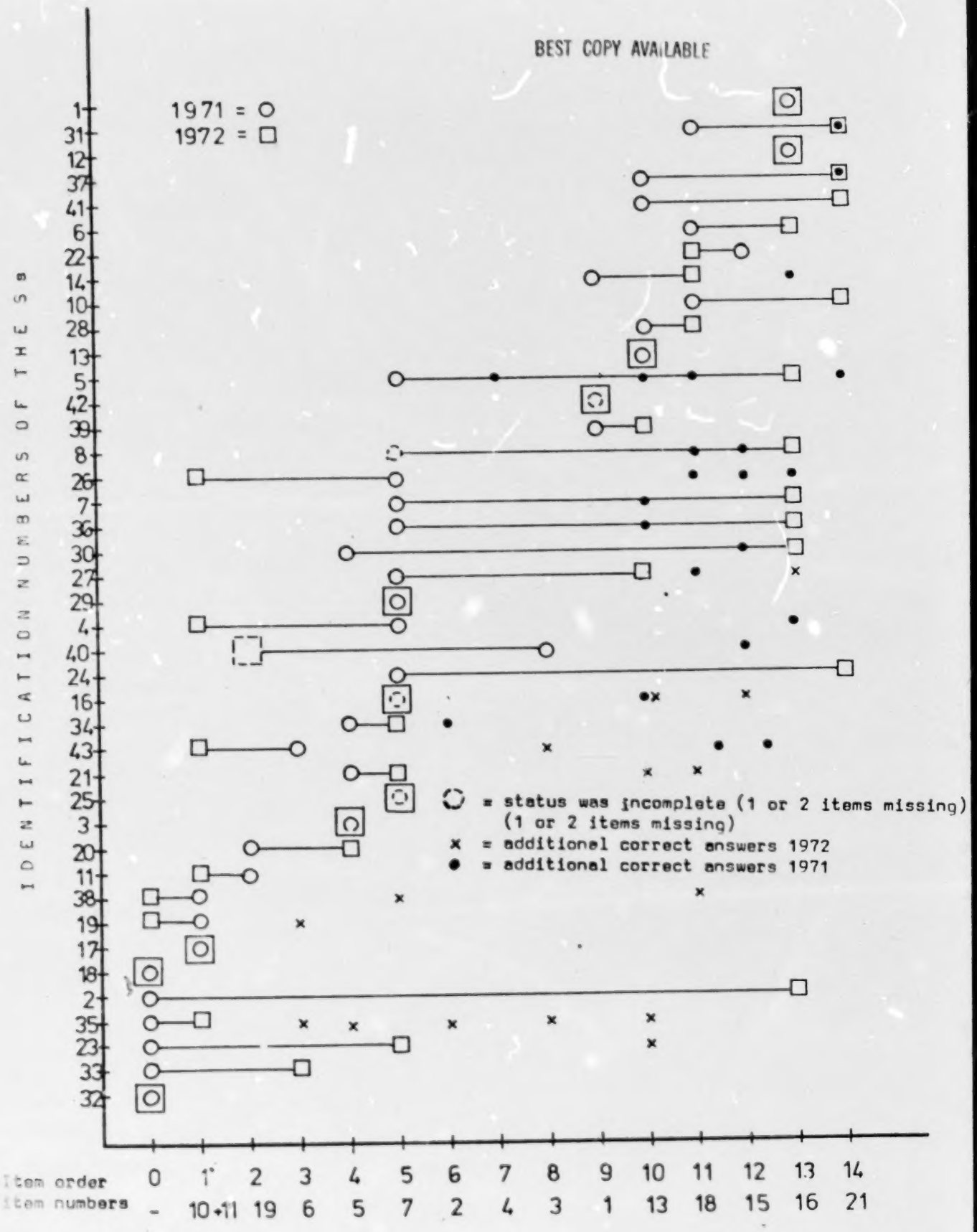

FIGURE 9 : CHANGES IN CONSERVATION STATUS OF EACH INDIVIDUAL CHILD ON THE SCALOGRAM ANALYZED SCALE FROM THIRD TO FOURTH ASSESSMENT

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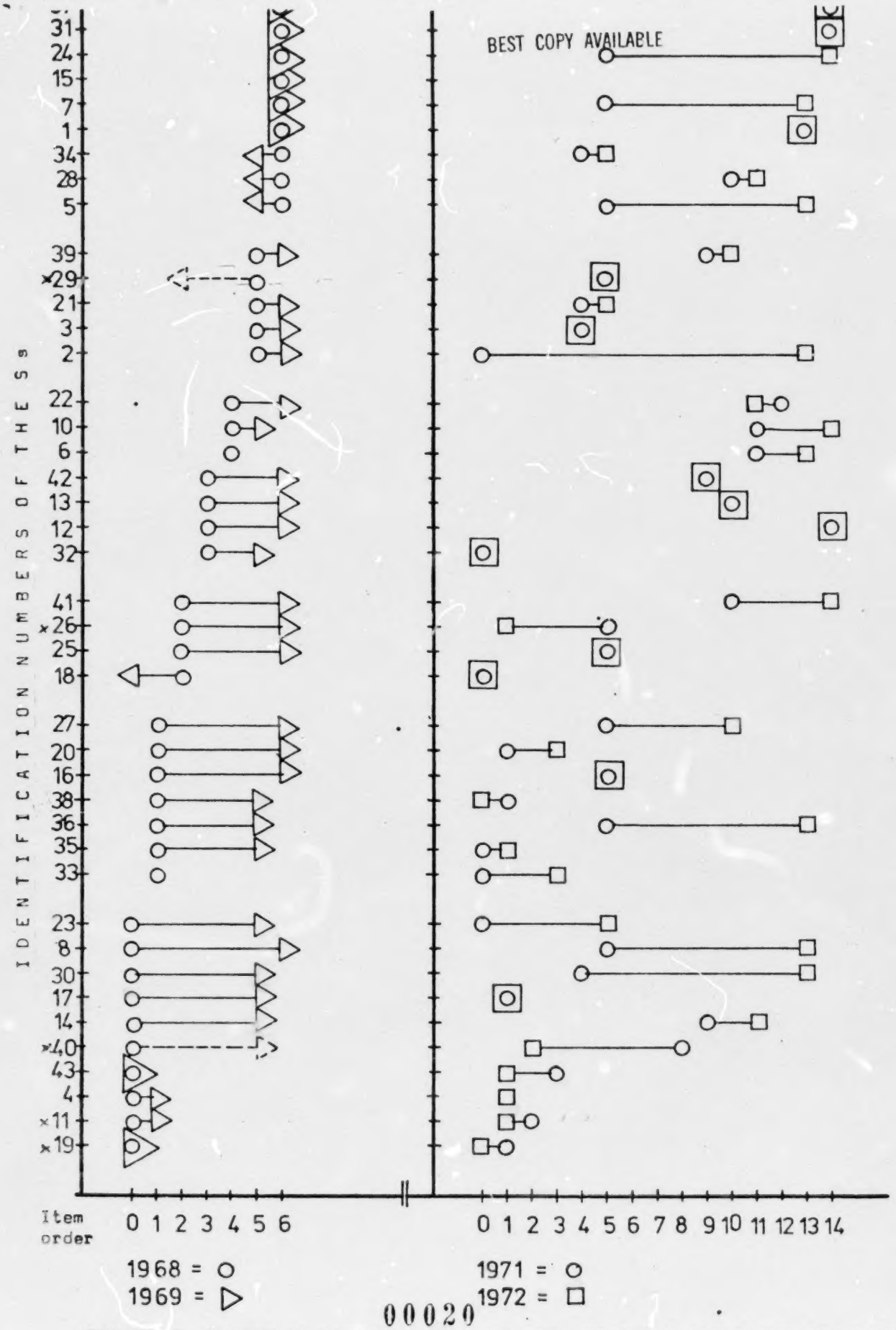

FIGURE 10: CHANGES IN COGNITIVE LEVEL OF EACH INDIVIDUAL CHILD OVER ALL ASSESSMENTS

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TABLE 2: Correlations between Total Item Scores

	1969	1971	1972
1968	.371	.535	.602
1969	-	.514	.613
1971	-	-	.702

TABLE 3: Correlations between Total Task Scores

	1969	1971	1972
1968	.412	.512	.604
1969	-	.509	.648
1971	-	-	.718

TABLE 4: Means of Total Item Scores over dichotomized groups (Conservers/nonconservers)

C/NC	1968 NC	1968 C	1969 NC	1969 C	1971 NC	1971 C	1972 NC	1972 C
1968	5.2	22.6	20.1	26.1	6.9	13.1	10.0	16.0
1971	8.7	18.9	18.9	27.3	5.5	14.6	8.8	17.2
1972	8.5	18.6	19.1	26.7	6.4	13.3	7.7	17.7